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BOOK REVIEWS AND NOTES.

THE MECHANISTIC CONCEPTION OF LIFE. By *Jacques Loeb, M.D., Ph.D., Sc.D.* Chicago: University Press, 1912. Pp. 232. Price \$1.50 net.

The ideal of science is to establish on a firm basis the mechanistic conception of life, and Prof. Jacques Loeb has been one of the most enthusiastic and efficient workers in this line of investigation. He has succeeded in performing a number of experiments whereby he has proved that the interference with the organs of animalcules produces effects analogous to the interference, and that certain actions depend on definite constitutions which he classifies as their tropisms, just as much as the sizes of wheels and cranks in machinery determine the movements of an engine. The book before us contains a number of articles which were used on different occasions either as lectures or as essays, and all of them characterize the tendency "to analyze life from a purely physico-chemical view-point." The first chapter is an English translation of Professor Loeb's address at the first international congress of monists at Hamburg, and may be considered as a general program of the mechanistic conception. The difficulty of this view comes in when we come to the properly psychical phenomena of the higher animals, especially man, and here Professor Loeb also insists on the principle that "all life phenomena can be unequivocally explained in physico-chemical terms," and he continues that even "our social and ethical life will have to be put on a scientific basis, and our rules of conduct must be brought in harmony with the results of scientific biology," and by "scientific" Professor Loeb understands physico-chemical.

Professor Loeb selects as most significant instances the tropisms of various animals. Referring to the specific life processes, he says that "if we can convince ourselves that these processes can be explained physico-chemically we may safely expect the same of such processes for which there exist *a priori* analogies in inanimate nature, as, e. g., for absorption and secretion."

Professor Loeb says: "The contents of life from the cradle to the bier are wishes and hopes, efforts and struggles, and unfortunately also disappointments and suffering. And this inner life should be amenable to a physico-chemical analysis? In spite of the gulf which separates us to-day from such an aim I believe that it is attainable. As long as a life phenomenon has not yet found a physico-chemical explanation it usually appears inexplicable. If the veil is once lifted we are always surprised that we did not guess from the first what was behind it.

"That in the case of our inner life a physico-chemical explanation is not beyond the realm of possibility is proved by the fact that it is already possible for us to explain cases of simple manifestations of animal instinct and will on

a physico-chemical basis; namely, the phenomena which I have discussed in former papers under the name of animal tropisms. As the most simple example we may mention the tendency of certain animals to fly or creep to the light."

This principle applied to ethics is explained thus: "If our existence is based on the play of blind forces and only a matter of chance; if we ourselves are only chemical mechanisms—how can there be an ethics for us? The answer is, that our instincts are the root of our ethics and that the instincts are just as hereditary as is the form of our body. We eat, drink, and reproduce not because mankind has reached an agreement that this is desirable, but because, machine-like, we are compelled to do so. We are active, because we are compelled to be so by processes in our central nervous system; and as long as human beings are not economic slaves the instinct of successful work or of workmanship determines the direction of their action. The mother loves and cares for her children, not because metaphysicians had the idea that this was desirable, but because the instinct of taking care of the young is inherited just as distinctly as the morphological characters of the female body. We seek and enjoy the fellowship of human beings because hereditary conditions compel us to do so. We struggle for justice and truth since we are instinctively compelled to see our fellow beings happy. Economic, social, and political conditions or ignorance and superstition may warp and inhibit the inherited instincts and thus create a civilization with a faulty or low development of ethics. Individual mutants may arise in which one or the other desirable instinct is lost, just as individual mutants without pigment may arise in animals; and the offspring of such mutants may, if numerous enough, lower the ethical status of a community. Not only is the mechanistic conception of life compatible with ethics: it seems the only conception of life which can lead to an understanding of the source of ethics."

These quotations are sufficient to characterize the tendency of the book. In the field of comparative physiology the unraveling of the mechanism of associative memory is the great discovery to be made in the realm of physiological morphology. While Professor Loeb has done good experimental work, he points out that there is a higher aim than to discover the laws of organization of the tissues, for we should endeavor to form new combinations from elements of living nature, just as the physicists and chemists form new combinations from the elements of living substance. In the field of fertilization much has been done of late which may almost be called sensational, for the process of fecundation is no better understood than before, and strange to say parthenogenesis has become an established fact, for we can experimentally prove that an egg may be fertilized by different stimuli without the introduction of a sperm. A special article is devoted to a discussion of the rôle which salts play in the preservation of life. At the end of the book Professor Loeb points out that the insight gained into the mutations that take place and the laws of heredity—the former represented by the labors of De Vries, the latter by the laws of Mendel—place before the experimental biologist the difficult task of producing favorable mutations by physico-chemical means. Nobody has thus far succeeded in this, although nothing warrants us to take it for granted that the task is beyond the power of science.

With regard to Professor Loeb's experiments directed towards the dis-

covery of mechanical causes of will, Dr. Leonard Keene Hirshberg sends the following detailed review:

"Professor Jacques Loeb, M.D., Ph.D., Sc.D., and Member of the Rockefeller Institute for Medical Research, has applied scientific methods of the biological laboratory to throw light upon the great ethical problem of free will. His researches are startling to say the least. Like the recent prophecy of Prof. A. E. Schaeffer, the great English physiologist, his report will bring down the condemnation of all creeds and churches upon his work.

"Although most of us will not at this time agree with Professor Loeb, although his deterministic conception of life is revolutionary in its discovered facts, at this moment we lack the laboratory and experimental data to deny Dr. Loeb's conclusions. Therefore in a perfectly fair spirit, without agreeing with or disputing his discovery, I shall present here with all technical matters omitted, the mass of newly exposed facts opened up to the world by the genius of this great savant.

"Perhaps not since Loewoenhoeck first observed the cell, since Jenner gave us a means of preventing smallpox, Koch and Pasteur proved bacteria to be concerned with diseases, Sir A. E. Wright exposed the mechanism of vaccination, and Ross with Manson proved the mosquito guilty of transmitting malaria, has there been such a startling announcement from the laboratories of the experimental sciences as this one of Dr. Loeb. All the problems of sociology, commerce, creeds, religions, ethical practice, finance, and community effort hinge upon the verification or refutation of his discovery.

"Through the writings of Schopenhauer he became interested in the problem of will. When as a student he read Munk's investigations on the brain he believed that they might serve as a starting point for an experimental analysis of will. Munk stated that he had succeeded in proving that every memory-image in a dog's brain is localized in a particular cell or group of cells and that any one of these memory-images can be extirpated at desire. Five years of experiments with sections and slices of brain proved to Dr. Loeb beyond doubt that Munk had become the victim of an error and that the method of brain operations may give data concerning the path of nerves in the central nervous system, but that it teaches little about the activities of brain processes.

"A better opportunity seemed to offer itself in the study of the comparative psychology of the lower animals in which the machinery for memory is developed but slightly or not at all. It seemed to him that some day it must become possible to discover the physico-chemical laws underlying the apparently random movements of such animals; and that the word 'animal will' was only the expression of our ignorance of the forces which prescribe to animals the direction of their apparently spontaneous movements just as certainly as gravity prescribes the movements of the planets.

"The scientific solution of the problem of will seemed then to consist in finding the forces which determine the movements of animals, and in discovering the laws according to which these forces act. Experimentally, the solution of the problem of will must take the form of forcing any number of individuals of a given species to move in a definite direction by means of their locomotor apparatus. Only if we succeed in this have we the right to assume that we know the force which under certain conditions seems to everybody

to be the will of the animal. But if one part only of the animal moves in this direction and the other does not, we have not succeeded in finding the force which determines the direction of the creature's movement.

"Some experiments on winged plant-lice may serve as an introduction to the methods of prescribing to animals the direction of their movements.

"In order to obtain the material, potted rose bushes infested with plant-lice are brought into a room and placed in front of a closed window. If the plants are allowed to dry out, the plant-lice, previously wingless, change into winged insects. After this metamorphosis the animals leave the plants, fly to the window, and there creep upward on the glass. They can easily be collected by holding a test-tube underneath and touching one insect at a time from above with a pen or pencil, thus causing them to drop into the test-tube. With these insects it may be shown that the direction of their movement toward the light is definitely determined—provided that they are healthy and that the light is not too weak. The experiment is so arranged that only a single source of light, that is, artificial light, is used.

"The insects place themselves with their heads toward the source of light and move toward it in as straight a line as the imperfection of their locomotor apparatus allows, approaching as near to the source of light as their prison (the test-tube) permits. When they reach the end of the test-tube which is directed toward the source of light, they remain there, perfectly still, in a closely crowded mass. If the test-tube is turned 180 degrees the lice again go straight toward the source of light until the interference of the glass stops their further progressive movements. It can be demonstrated in these insects that the direction of their forward movement is just as much governed by the source of light as the direction of the movement of the planets is determined by the force of gravity.

"The following is an example of animals, which when attracted by light are forced to turn their heads or more often their bodies toward the source of light, and when repelled by light are pointed away from and compelled to move in the opposite direction.

"The plant-lice serve only as one example. All animals influenced by light are in reality machines by which light may be measured. According to the laws of light its strength varies with the angle at which the light strikes the surface of the animal. The animal is pointed towards or away from the light in such a way that symmetrical parts of its sensitive surface are struck at about the same angle. In the presence of only one source of light this condition is fulfilled if the axis of the animal moves in the direction of the rays of light. In this case the speed of the changes which take place on both sides of the animal is the same and there is no reason why it should deviate from this direction in its movements.

"Experiments in the effect of light on plants as well as on the perception of light have shown that the effect of light equals the product of the strength by the time that the light is acting. This law is identical with the general law of Bunsen and Roscoe which states that the chemical effect of light is within wide limits equal to this product. It is not known whether or not Bunsen's law holds good for the animals affected by light. If it does, this law will have to be substituted for what the metaphysician calls 'the will' of these animals.

"Many animals show no 'heliotropism' or light influence at all; many show only a slight response to light, while others show it in a degree as pronounced as do winged plant lice. The problem therefore presented itself to Professor Loeb of artificially producing heliotropism, or response of a creature to the influence of light, in animals which, under natural conditions, show no heliotropism. If small crabs of a fresh-water pond or lake are taken with a net at noontime or in the afternoon and placed in an aquarium which is illuminated from one side only, it is often found that these animals move about in the vessel pretty much at random and distribute themselves irregularly. Some seem to move toward the source of light, others in the opposite direction, and the majority perhaps pay no attention to the light.

"This condition changes instantly if we add to the water some acid, preferably carbonic acid, which easily penetrates the cells of the animal. All the individuals become active and approach the light. They move in as straight a line as the imperfection of their swimming movements permits, toward the source of light, and remain there closely crowded together on the illuminated side of the vessel. If the vessel is reversed they go directly back again to the lighted side of the vessel. Every other acid acts like carbonic acid, and alcohol acts in the same manner, only more weakly and much more slowly. Animals which were previously indifferent to light become, under carbonic acid treatment, complete slaves of the light.

"The acid acts as a sensitizer. The light produces chemical changes—for instance, oxidation—on the surface of the animal, especially in the eye. The mass of substance which is acted upon by the light is often relatively small, so that even when the light strikes the crab on one side only, the difference in the chemical changes on the two sides of the body remains still too small to call for a difference in tension or action in the muscles of the two sides of the body, sufficient to turn the animal toward the source of light. But if an acid is added, this could act increasing the active parts of the substance which undergoes a chemical change. Thus the acid makes the animal more strongly attracted towards the light by increasing the active mass of the sensitive substance on its body.

"Some authors have, it seems, worked only with animals which were not pronouncedly 'heliotropic' or influenced by light and whose photo-sensitivity wavered about the threshold of stimulation. Professor Loeb believed that observations upon animals which are not sufficiently photo-sensitive have caused many writers to assert that animals do not place themselves directly in the line of the rays of light, but that they first have to learn the right direction to go. Every striking experiment contradicts this assertion. The larvæ of a small marine animal develop entirely in the dark. If the eggs filled with mature larvæ are placed in a watch crystal filled with sea-water in the dark, the larvæ emerge at once to the side of the crystal nearest to the window. They were therefore pronouncedly attracted by light before they came under the influence of the light, literally before they are born.

"In experiments with winged plant-lice, Professor Loeb often found that after having gone through the heliotropic reactions a few times they react much more quickly to light than at the beginning. This might be interpreted as a case of 'learning.' In so far as it is not a case of lessening of the stickiness of the feet or the removal of some other purely mechanical factor which

retards the rate of movement, it may be brought about by the carbonic or lactic acids produced through the muscular activity.

"It is a well-known fact that during sexual maturity special substances are formed which influence various organs. For instance, Professor Loeb has found that the substances which are set free by the bursting of an egg causes special sensitiveness in the non-pregnant animal.

"It is a common phenomenon that animals in certain larval stages are positively attracted by light, while in others they are not sensitive to light or are even negatively repelled by it. This change in the heliotropic sensitiveness produced by certain chemical products in the animal body, is of great biological significance.

"The fact that ants and bees become positively attracted to a source of illumination at the time of sexual maturity plays an important rôle in the vital economy of these creatures. As is well known the mating of these insects takes place during the so-called nuptial flight. Professor Loeb found that among the male and female ants of a nest the sensitiveness to light increases steadily up to the time of the nuptial flight and that the direction of their flight follows the direction of the rays of the sun. He gained the impression that this nuptial flight is merely the consequence of a very highly developed heliotropic or light sensitiveness. The following is an experiment which shows that the case is similar among the bees. The bees were ready to swarm out of the opening of the box used for the experiment when the dark covering of the box was removed so that the light entered it from above. The sensitiveness of the animals to light was so great that they crept upward within the box, following the direction of the light rays, and were not able to make the nuptial flight. Thus, according to these observations the bees at the time of the nuptial flight are *positively heliotropic* machines.

"The attempt has been made to prove that organisms are attuned to a certain intensity of light and so regulate their heliotropism, that they invariably reach that intensity of light which is best suited to their well-being. Professor Loeb believed that this was a suggestion forced upon the investigators by the extreme application of the theory of natural selection. He made experiments upon a large number of animals, but, with a clear arrangement of the physical conditions of the experiment, he has never found a single indication of such an adaptation.

"Animals are in general symmetrically built, and the muscles of the right and left sides of the body usually act symmetrically. There are animals, however, which move sideways, for instance, certain crabs like the fiddler crab. It was also found out that they go sideways toward the light. Professor Loeb says that in the fiddler crab there is an entirely different connection between the retina and the locomotor muscles from that in other crabs, and that there is a special peculiarity in regard to the function of the two eyes whereby they do not act like symmetrical elements.

"These facts may suffice to explain his point of view. To him it was a question of making the fact of psychology accessible to analysis by means of physical chemistry. In this way it is already possible to reduce a set of movements, namely the influence of light, to simple mechanical relations. Many animals, because their body structure is not only anatomically, but also

chemically symmetrical, are obliged to direct their bodies in a certain way in relation to certain centers of force, as, for instance, the course of light, an electric current, the center of gravity of the earth, or some chemical substances. This direction is automatically regulated according to the law of size and shape. The application of this law to this set of influences is thus made possible. Professor Loeb considers it unnecessary to give up the term 'comparative psychology,' but is of the opinion that the facts and discoveries of animal psychology, under the influence of the experiments of himself and others, will be different from the contents of speculative psychology. But he also believes that the further development of this subject will fall more to the lot of biologists trained in physical chemistry than to the specialists in psychology or zoology, for it is in general hardly to be expected that zoologists and psychologists who lack a physico-chemical training will feel attracted to the subject of the influence of light and other external things in an animal's surroundings, and a study of their effects.

"Professor Loeb says concerning the possible application of these investigations that the investigations of the conditions which produce them may be of importance for the study of insanity in man. If by means of an acid we call forth in an animal otherwise indifferent to light an effect which drives it irresistibly into a flame; if the same thing can be brought about by means of an extract of the reproductive glands he believes a group of facts have been given within which the analogies necessary for a study of insanity can be called forth experimentally and can then be investigated. Says Professor Loeb: 'These experiments may also attain a similar value for morality and ethics. The highest manifestation of ethics, namely, the condition that human beings are willing to sacrifice their lives for an idea, is comprehensible neither from the utilitarian standpoint nor from that of the categorical imperative or the "still small voice." It might be possible that under the influence of certain ideas chemical changes, for instance, internal secretions within the body, are produced which increase the sensitiveness to certain stimuli to such an unusual degree that such people become slaves to certain stimuli just as crabs become slaves to the light when carbon dioxide is added to the water. Since Pawlow and his pupils have succeeded in causing the secretion of saliva in the dog by means of optic and acoustic signals, it no longer seems strange to us that what the philosopher terms an "idea" is a process which can cause chemical changes in "the body."

DIE MECHANIK IN IHRER ENTWICKLUNG. Historisch-kritisch dargestellt von
Dr. Ernst Mach. Leipsic: Brockhaus, 1912.

It may well be a source of gratification to Professor Mach that forty years after the first utterance of his favorite principles and almost thirty years after their appearance in the more comprehensive form of his *Mechanik*, there comes a demand for a seventh edition of this work. In his preface to this revised and enlarged edition the venerable scientist relates something of the history of the book, and the reception accorded it and the principles for which it stands. When the author's ideas were first promulgated they not only met with little recognition and encouragement but with general opposition. When Kirchhoff published his views two years later Mach was accused of having